Vectors

Applications to Meteorology

Vectors have many different uses in meteorology. They're used to calculate wind shear, determine cirrus blow-off, or to determine the effects of crosswinds on aircraft. It is important to understand what they are and how they apply to all the different aspects of weather.

This period of instruction will cover meteorological vectors and how they apply.

Objectives

- TERMINAL LEARNING OBJECTIVE : Define a vector and how it applies to meteorology.
- ENABLING LEARNING OBJECTIVE : Given vectors, find the resultant using the various methods discussed.

What is a Vector?

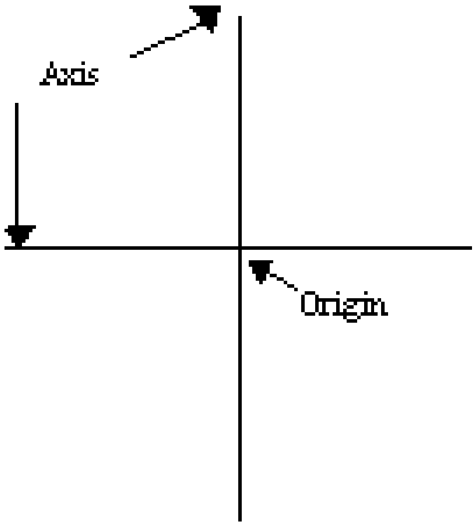
Any quantity (such as force, velocity or acceleration) which has both magnitude and direction.

Vectors can be represented in 2 ways

- Mathematically - 2708 (Westward at 08 knots)
- Graphically - Using an arrow represents the vector.
- The arrow length is proportional to the magnitude of the vector. It points in the direction an object is moving. It is plotted on a coordinate system to insure all vectors are represented in the same scale and correct orientation.

Drawing a graph

- A graph should be used to ensure the vector is proportionate.
- Axis - One of two perpendicular lines used to define the coordinate system.
- Origin - The intersection of the two axes. The end point of the vector is plotted at the origin.

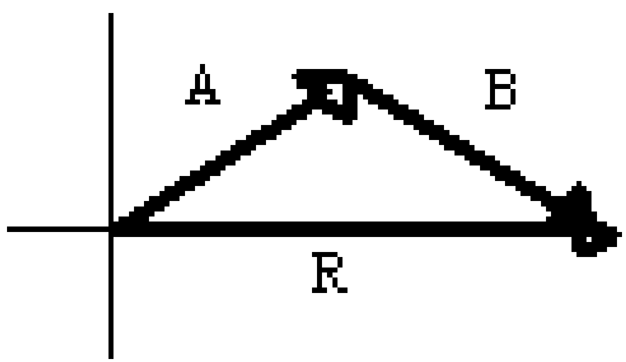


Vector Operations

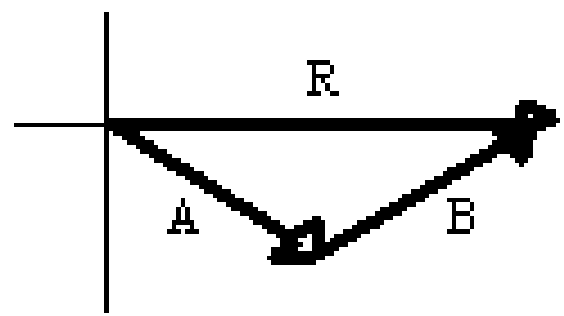
- There are a couple different methods for calculating vectors.
- “Head to Tail” method
- “Tail to Tail” method

Vector Addition “Head to Tail”

- 1. Construct x, y coordinate system
- 2. Select a scale and plot vector "A" to scale
- 3. Plot vector "B" to scale with proper orientation using another coordinate system on the head of vector "A".
- 4, Draw resultant vector "R" from origin of "A" to the head of last vector being added "B"
- 5. Order of addition makes no difference.



A + B = R



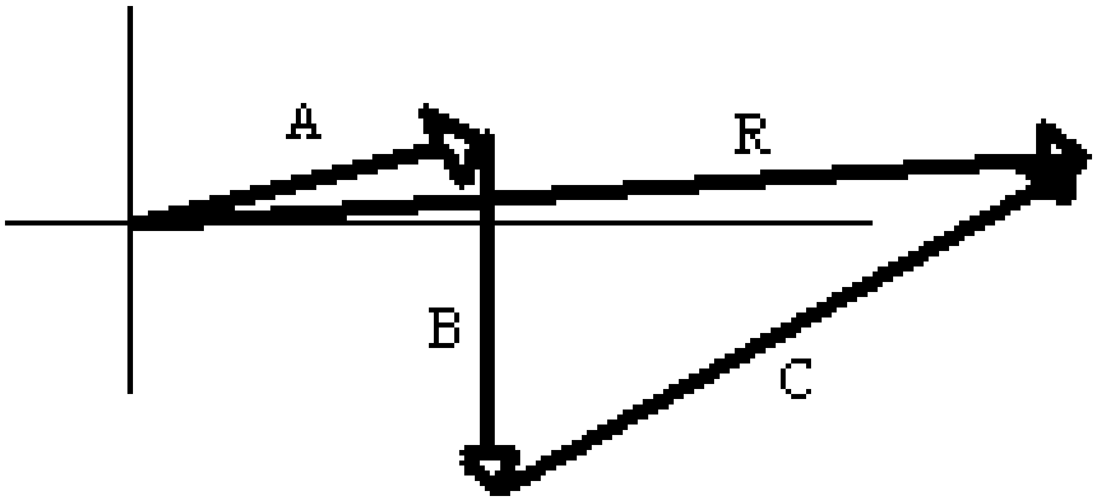
B + A = R

Resultant of forces - The direction of a parcel's movement will be in the direction found by the vector sum of all of the forces acting on the parcel. The magnitude of the change in the parcel movement is proportional to the magnitude of the resultant.

Average wind for a layer - Divide the magnitude only by 2.

Addition of several vectors

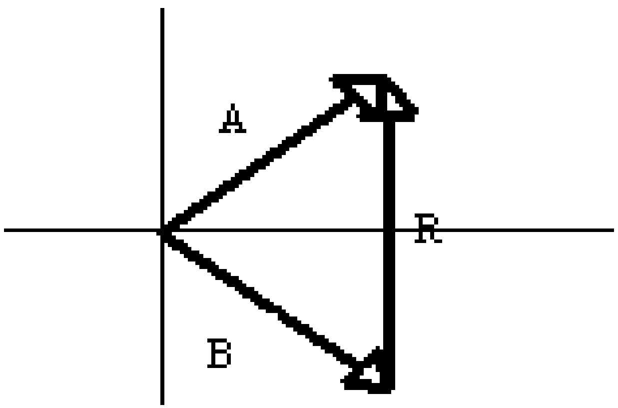
- This may be accomplished by using the same “head to tail” method.
- Again, the order does not make a difference.
- If average speed is necessary, the number of vectors must be divided into the resultant speed.



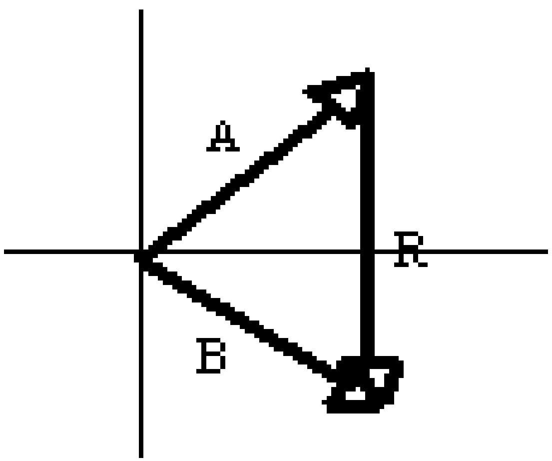
$$A + B + C = R$$

“Tail to Tail” Method

- Construct X, Y coordinate system.
- Select scale and draw both "A" & "B" to scale with both tails at the origin of coordinate system.
- For A-B, Draw resultant "R" from the head of the vector being subtracted "B" to the head of the vector being subtracted from "A"
- Note : Order does make a difference. A-B does not equal B-A. Magnitudes would be the same, but direction would be 180 degrees out.



R = A - B

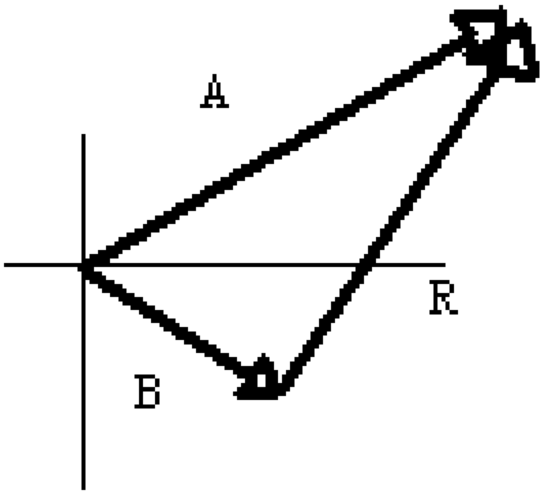


R = B - A

Meteorological Applications

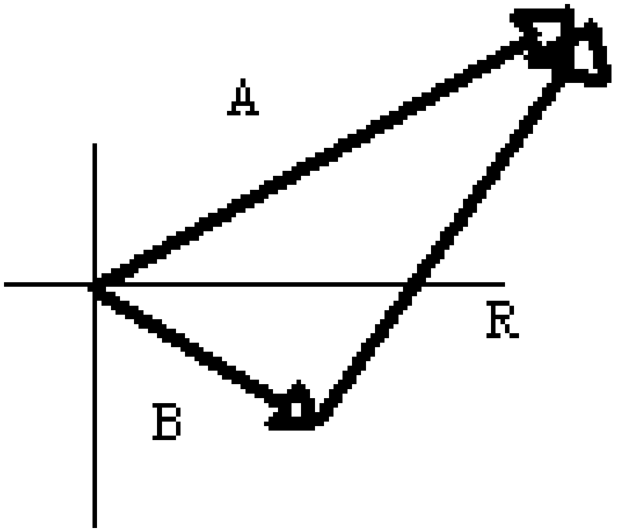
- Calculate wind shear
  - The change of wind speed and / or direction, in the vertical or horizontal
- Determine the movement of cirrus blow off

Example : A = 700mb, winds B = 850mb winds, R = Wind Shear



Wind shear is found using the tail to tail method, subtracting the lower level (850mb) from the upper level (700mb) winds. The resultant is the wind shear.

Example : A=Winds aloft, B = Cell Movement, R = Cirrus Blowoff



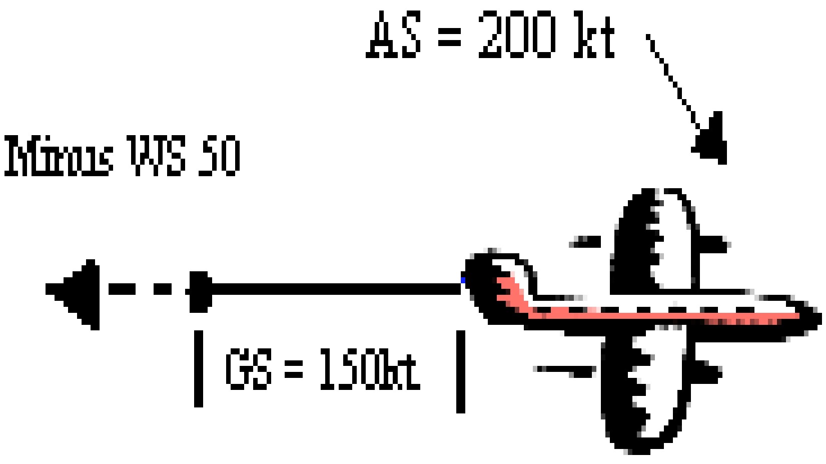
Cirrus starts at the origin and is blown off by upper level wind flow, vector "A". During the same time, the thunderstorm moves along vector "B". From the viewpoint of the thunderstorm, it appears that cirrus has blown off in direction "R".

Effects on Aircraft

Commonly Used Terms

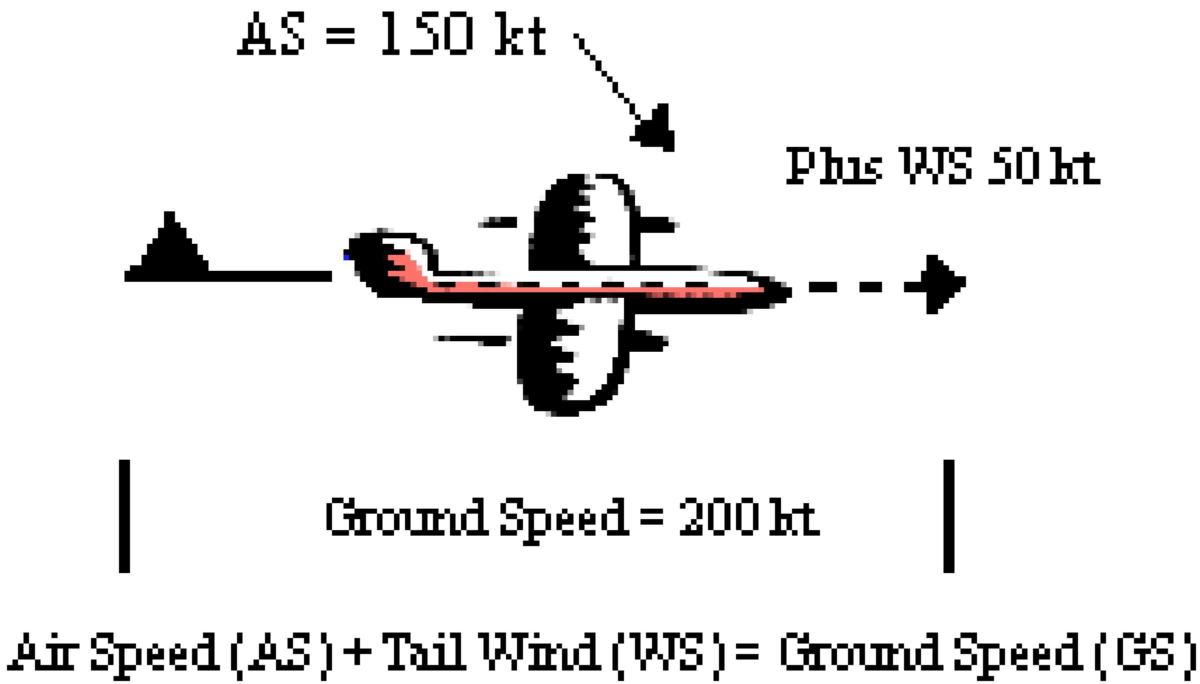
- 1. Air speed - The speed at which an aircraft is flying relative to the air.
- 2. Ground speed - The speed at which an aircraft is flying relative to the ground.
- 3. Head wind - The component of the wind vector that is parallel to the aircraft's direction of motion, opposes the aircraft's motion, and will result in a decreased ground speed.
- 4. Tail Wind - The component of the wind vector that is parallel to the aircraft's direction of motion, assists the aircraft's motion, and will result in a increased ground speed.
- 5. Cross Wind - The component of the wind crosses the aircraft's path. It will require a change in the aircraft's heading in order to maintain the desired course.

Calculating ground speed with a head wind

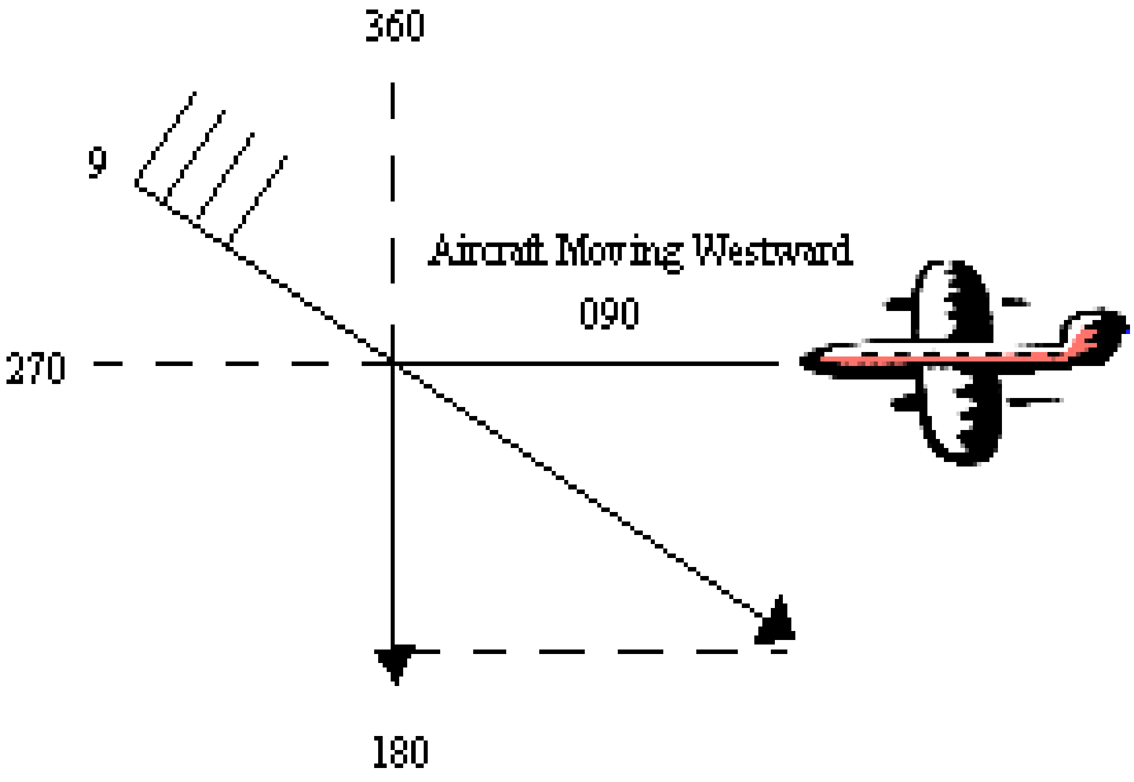


Air Speed (AS) - Head Wind (WS) = Ground Speed (GS)

Calculating ground speed with a tail wind



Calculating a crosswind



We have covered vectors and the various methods used to calculate them. We also covered how they can be applied to meteorological operations. Do I have any questions at this time?